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Remarks

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DECLARATION

I, Koichi OISHI Patent Attorney, of OISHI & PARTNERS, 4th Floor, Kanda-ON Building, 1-10, Kandasudacho, Chiyoda-ku, Tokyo 101-0041 Japan, hereby certify that I am the translator of the certified official copy of the documents in respect of an application for a Patent filed in Japan on August 12, 2002 under Patent Application No. 2002-234281 and that the following is a true and correct translation to the best of my knowledge and belief.

Koichi OISHI
Patent Attorney

Dated: February 15, 2007

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[TITLE OF THE INVENTION]

OPTICAL RECORDING MEDIUM AND OPTICAL RECORDING METHOD

[CLAIMS]

[Claim 1] An optical recording medium comprising a substrate and a recording layer formed over the substrate and being adapted so that a recording mark is formed at a predetermined region of the recording layer by projecting a laser beam having a wavelength of 350 nm to 450 nm, the recording layer comprising a first reaction layer containing one element selected from a group consisting of C, Si, Ge and Sn as a primary component and a second reaction layer disposed adjacent with the first reaction layer and containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component, the recording mark being constituted as a region where the primary component element contained in the first reaction layer and the primary component element contained in the second reaction layer mix with each other by the irradiation with the laser beam.

[Claim 2] An optical recording medium in accordance with Claim 1, which further comprises a light transmission layer provided opposite to the substrate as viewed from the recording layer and wherein the laser beam is projected the optical recording medium from the side of the light transmission layer.

[Claim 3] An optical recording medium in accordance with Claim 2, which further comprises a first dielectric layer provided between the

light transmission layer and the recording layer and a second dielectric layer provided between the substrate and the recording layer.

[Claim 4] An optical recording medium in accordance with Claim 3, which further comprises a reflective layer between the substrate and the second dielectric layer.

[Claim 5] An optical recording medium in accordance with any one of Claims 1 to 4, the optical recording medium is constituted as a write-once type optical recording medium.

[Claim 6] An optical recording method comprising a step of projecting a laser beam having a wavelength of 350 nm to 450 nm onto an optical recording medium comprising a substrate and a recording layer provided over the substrate and comprising a first reaction layer containing one element selected from a group consisting of C, Si, Ge and Sn as a primary component and a second reaction layer disposed adjacent with the first reaction layer and containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component and mixing the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component, thereby forming a recording mark.

[Claim 7] An optical recording method in accordance with Claim 6, wherein the wavelength of the laser beam and a numerical aperture NA of an objective lens for converging the laser beam are selected so as to satisfy $\lambda/NA \leq 640$ nm.

[Claim 8] An optical recording method in accordance with Claim 6 or 7, wherein the optical recording medium further comprises a light transmission layer provided opposite to the substrate as viewed from the recording layer and is constituted so that the laser beam is projected thereonto from the side of the light transmission layer.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[FIELD OF THE INVENTION]

The present invention relates to an optical recording medium and a method for optically recording information in the optical recording medium and, particularly, to an optical recording medium whose recording layer includes a plurality of reaction layers and an optical recording method for optically recording data in the optical recording medium having such a structure.

[0002]

[DESCRIPTION OF THE PRIOR ART]

Optical recording media such as the CD, DVD and the like have been widely used as recording media for recording digital data. These optical recording media can be roughly classified into optical recording media such as the CD-ROM and the DVD-ROM that do not enable writing and rewriting of data (ROM type optical recording media), optical recording media such as the CD-R and DVD-R that enable writing but not rewriting of data (write-once type optical recording media), and optical recording media such as the CD-RW and DVD-RW that enable rewriting of data (data rewritable type optical recording media).

[0003]

As well known in the art, data are generally recorded in a ROM type optical recording medium using prepits formed in a substrate in the manufacturing process thereof, while in a data rewritable type optical recording medium a phase change material is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by phase change of the phase change material.

[0004]

On the other hand, in a write-once type optical recording medium, an organic dye such as a cyanine dye, phthalocyanine dye or azo dye is generally used as the material of the recording layer and data are recorded utilizing changes in an optical characteristic caused by chemical change of the organic dye, which change may be accompanied by physical deformation.

[0005]

However, since an organic dye is degraded when exposed to sunlight or the like, it is difficult to improve long-time storage reliability in the case where an organic dye is used as the material of the recording layer. Therefore, it is desirable for improving long-time storage reliability of the write-once type optical recording medium to form the recording layer of a material other than an organic dye. As disclosed in Japanese Patent Application Laid Open No. 62-204442, an optical recording material formed by laminating a plurality of reaction layers each containing an inorganic material is known as an example of an optical recording medium whose recording layer is formed of a material other than an organic dye. As the material for forming such a recording layer, it is necessary to select a material capable of considerably absorbing a laser beam to be used for recording data.

[0006]

[PROBLEMS TO BE SOLVED BY THE INVENTION]

On the other hand, a next-generation type optical recording medium that offers improved recording density and has an extremely high data transfer rate has been recently proposed. In such a next-generation type optical recording medium, the achievement of increased recording capacity and extremely high data transfer rate inevitably requires the diameter of the laser beam spot used to record and reproduce data to be reduced to a very small size. In order to reduce the laser beam spot diameter, it is necessary to increase the numerical aperture of the objective lens for condensing the laser beam to 0.7 or more, for example, to about 0.85, and to shorten the wavelength of the laser beam to 450 nm or less, for example, to about 400 nm.

[0007]

Therefore, in the case where a plurality of reaction layer each formed of an inorganic material are used as a recording layer of the next-generation type optical recording medium, it is necessary as the inorganic material for forming the recording layer of the next-generation type optical recording medium to select an inorganic material capable of considerably absorbing a laser beam having a wavelength included in a blue wavelength region unlike an inorganic material used in a CD type optical recording medium or a DVD type optical recording medium and having a property of considerably absorbing a laser beam having a wavelength included in a red wavelength region.

[0008]

On the other hand, increasing concern about global atmospheric problems further makes it necessary to fabricate optical recording media with materials put minimal load on the environment.

[0009]

It is therefore an object of the present invention to provide an optical recording medium whose recording layer is constituted by a plurality of reaction layers each containing an inorganic material and in which data can be recorded using a laser beam having a wavelength included in a blue wavelength region and which can reduce load applied onto the environment.

[0010]

Another object of the present invention is to provide an optical recording method for recording data in such an optical recording medium.

[0011]

[MEANS FOR SOLVING THE PROBLEMS]

The inventors of the present invention pursued a study about an inorganic material which can sufficiently absorb a laser beam having a wavelength included in a blue wavelength region and put minimal load on the environment and, as a result, made the discovery that C, Si, Ge and Sn could sufficiently absorb a laser beam having a wavelength included in a blue wavelength region and put minimal load on the environment. The present invention is based on this finding and the above object of the present invention can be accomplished by an optical recording medium comprising a substrate and a recording layer formed over the substrate and being adapted so that a recording mark is formed at a predetermined region of the recording layer by projecting a laser beam having a wavelength of 350 nm to 450 nm, the recording layer comprising a first reaction layer containing one element selected from a group consisting of C, Si, Ge and Sn as a primary component and a second reaction layer disposed adjacent with the first reaction layer and

containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component, the recording mark being constituted as a region where the primary component element contained in the first reaction layer and the primary component element contained in the second reaction layer mix with each other by the irradiation with the laser beam.

[0012]

In the optical recording medium of the present invention, when the recording layer is irradiated with a laser beam from the side of the light transmission layer when data are to be recorded in the optical recording medium, the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component partially or totally diffuse by the irradiation with the laser beam to mix with each other, whereby a recording mark is formed. At this time, the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component can mix with each other within the beam spot of the laser beam. Thus, since the reflection coefficient of a mixed region of the recording layer where the recording mark is formed and that of other regions of the recording layer with respect to a laser bream for reproducing data are greatly different from each other, it is possible to reproduce the recorded information using the laser beam for reproducing data based on the difference in the reflection coefficient therebetween with a high sensitivity.

[0013]

In the optical recording medium of the present invention, since the first reaction layer and the second reaction layer contain C, Si, Ge or Sn as a primary component and these elements can effectively absorb a

laser beam having a wavelength included in a blue wavelength region, it is possible to record information therein using the laser beam having a wavelength included in a blue wavelength region suitable for achieving high recording density and a high data transfer rate. In addition, in the optical recording medium of the present invention, since the first reaction layer and the second reaction layer contain C, Si, Ge or Sn as a primary component, it is possible to reduce load applied onto the environment in comparison with a conventional optical recording medium. In particular, since C and Si are very inexpensive, the cost of the optical recording medium can be lowered.

[0014]

In the present invention, the statement that the reaction layer contains a certain element as a primary component means that the content (atomic %) of the element is maximum among the elements contained in the reaction layer. Further, in the present invention, the recording mark means a region formed by mixing at least parts of the region of the recording layer irradiated with the laser beam when data are to be recorded in the optical recording medium and containing a mixture of the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component.

[0015]

Furthermore, in the present invention, it is preferable for the optical recording medium to further include a light transmission layer provided opposite to the substrate as viewed from the recording layer and to be constituted so that the laser beam is projected thereonto from the side of the light transmission layer. Moreover, in the present invention, the optical recording medium further includes a first dielectric layer

provided between the light transmission layer and the recording layer and a second dielectric layer provided between the substrate and the recording layer. In the case where the optical recording medium further includes a first dielectric layer provided between the light transmission layer and the recording layer and a second dielectric layer provided between the substrate and the recording layer, it is possible to prevent the substrate and the light transmission layer from being thermally deformed due to the mixing of the recording layer and prevent the optical recording medium from being corroded. Therefore, it is possible to more effectively prevent the optically recorded information from being degraded for a long time period.

[0016]

Furthermore, in the present invention, it is preferable for the optical recording medium to further include a reflective layer between the substrate and the second dielectric layer. In the case where the optical recording medium further include a reflective layer between the substrate and the second dielectric layer, it is possible to obtain a reproduced signal having a high C/N ratio by a multiple interference effect after optically recording data.

[0017]

In the present invention, the optical recording medium is preferably used as a write-once type optical recording medium.

[0018]

Further, the optical recording method according to the present invention is characterized by comprising a step of projecting a laser beam having a wavelength of 350 nm to 450 nm onto an optical recording medium comprising a substrate and a recording layer provided over the substrate and comprising a first reaction layer containing one element

selected from a group consisting of C, Si, Ge and Sn as a primary component and a second reaction layer disposed adjacent with the first reaction layer and containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component and mixing the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component, thereby forming a recording mark.

[0019]

According to the optical recording method of the present invention, when the laser beam is projected onto the recording layer from the side of the light transmission layer, the element contained in the first reaction layer as a primary component and the element contained in the second reaction layer as a primary component partially or totally diffuse by the irradiation with the laser beam to mix with each other, whereby a recording mark is formed. As a result, the reflection coefficient of a mixed region of the recording layer where the recording mark is formed and that of other regions of the recording layer with respect to a laser bream for reproducing data are greatly different from each other and a sufficiently large difference in the reflection coefficient is generated. Further, according to the optical recording method of the present invention, since data are optically recorded in the optical recording medium using the laser beam having a wavelength included in a blue wavelength region, it is possible to easily achieve high recording density and a high data transfer rate.

[0020]

Further, in the optical recording method of the present invention, it is preferable to use a laser beam and an objective lens for converging the laser beam whose numerical aperture NA and wavelength λ satisfy

$\lambda/NA \leq 640$ nm. In the case where the wavelength of the laser beam and the numerical aperture of the objective lens are set in this manner, since the beam spot of the laser beam can be markedly reduced, it is possible to more easily achieve high recording density and a high data transfer rate.

[0021]

In the optical recording method of the present invention, it is preferable for the optical recording medium to further include a light transmission layer provided opposite to the substrate as viewed from the recording layer and to be constituted so that the laser beam is projected thereonto from the side of the light transmission layer.

[0022]

[DESCRIPTION OF THE PREFERRED EMBODIMENTS]

Hereinafter, a preferred embodiment of the present invention will now be explained with reference to accompanying drawings.

[0023]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium that is a preferred embodiment of the present invention.

[0024]

As shown in Figure 1, an optical recording medium 10 according to this embodiment is constituted as a write-once type optical recording medium and includes a substrate 11, a reflective layer 12 formed on the surface of the substrate 11, a second dielectric layer 13 formed on the surface of the reflective layer 12, a recording layer 14 formed on the surface of the second dielectric layer 13, a first dielectric layer 15 formed on the surface of the recording layer 14 and a light transmission layer 16 formed on the surface of the first dielectric layer 15. A hole 17 is formed at a center portion of the optical recording medium 10. In this

embodiment, data are recorded in and reproduced from the optical recording medium 10 having such a structure by projecting a laser beam from the side of the light transmission layer 16.

[0025]

The substrate 11 serves as a support for ensuring mechanical strength required for the optical recording medium 10 and grooves 11a and lands 11b are alternately formed on the surface of the substrate 11. The grooves 11a and/or lands 11b serve as a guide track for the laser beam L10 when data are to be recorded or when data are to be reproduced. In this embodiment, the substrate 11 has a thickness of about 1.1 mm. The material used to form the substrate 11 is not particularly limited and substrate 11 can be formed of glass, ceramic, resin or the like, for example. Among these, resin is preferably used for forming the substrate 11 since resin can be easily shaped. Illustrative examples of resins suitable for forming the substrate 40 include polycarbonate resin, acrylic resin, epoxy resin, polystyrene resin, polyethylene resin, polypropylene resin, silicone resin, fluoropolymers, acrylonitrile butadiene styrene resin, urethane resin and the like. Among these, polycarbonate resin is most preferably used for forming the substrate 11 from the viewpoint of easy processing and the like.

[0026]

The reflective layer 12 serves to reflect the laser beam L10 entering through the light transmission layer 16 so as to emit it from the light transmission layer 16. The thickness of the reflective layer 12 is not particularly limited but is preferably from 10 nm to 300 nm, more preferably from 20 nm to 200 nm. The material used to form the reflective layer 12 is not particularly limited insofar as it can reflect a laser beam, and the reflective layer 12 can be formed of Mg, Al, Ti, Cr, Fe,

Co, Ni, Cu, Zn, Ge, Ag, Pt, Au and the like. Among these materials, it is preferable to form the reflective layer 12 of a metal material having a high reflection characteristic, such as Al, Au, Ag, Cu or alloy containing at least one of these metals, such as alloy of Al and Ti. In the present invention, it is not absolutely necessary to provide the reflective layer 12 in the optical recording medium but in the case where the reflective layer 12 is provided in the optical recording medium, it is possible to easily obtain a high reproduced signal (C/N ratio) by a multiple interference effect.

[0027]

The first dielectric layer 15 and the second dielectric layer 13 serve to protect the recording layer 14 formed therebetween . Degradation of data optically recorded in the recording layer 14 can be prevented over a long period by the first dielectric layer 15 and the second dielectric layer 13. Further, since the second dielectric layer 13 also serves to prevent the substrate 11 and the like from being deformed by heat, it is possible to effectively prevent jitter and the like from becoming worse due to the deformation of the substrate 11 and the like.

[0028]

The dielectric material used to form the first dielectric layer 15 and the second dielectric layer 13 is not particularly limited insofar as it is transparent and the first dielectric layer 15 and the second dielectric layer 13 can be formed of a dielectric material containing oxide, sulfide, nitride or a combination thereof, for example, as a primary component. More specifically, in order to prevent the substrate 11 and the like from being deformed by heat and thus protect the first recording layer 31 and the second recording layer 32, it is preferable for the first dielectric layer 15 and the second dielectric layer 13 to contain at least one kind of

dielectric material selected from the group consisting of Al_2O_3, AlN, ZnO, ZnS, GeN, GeCrN, CeO, SiO, SiO_2, SiN and SiC as a primary component and it is more preferable for the first dielectric layer 15 and the second dielectric layer 13 to contain $ZnS \cdot SiO_2$ as a primary component. The first dielectric layer 15 and the second dielectric layer 13 may be formed of the same dielectric material or of different dielectric materials. Moreover, at least one of the first dielectric layer 15 and the second dielectric layer 13 may have a multi-layered structure including a plurality of dielectric films.

[0029]

Here, the statement that the first dielectric layer 15 or the second dielectric layer 13 contains a certain dielectric material means that the content of the dielectric material is maximum among components contained in the first dielectric layer 15 or the second dielectric layer 13 and $ZnS \cdot SiO_2$ means a mixture of ZnS and SiO_2.

[0030]

The thickness of the first dielectric layer 15 and the second dielectric layer 13 is not particularly limited but is preferably from 3 nm to 200 nm. If the first dielectric layer 15 or the second dielectric layer 13 is thinner than 3 nm, it is difficult to obtain the above-described advantages. On the other hand, if the first dielectric layer 15 or the second dielectric layer 13 is thicker than 200 nm, it takes a long time to form the first dielectric layers 15 and the second dielectric layers 13, thereby lowering the productivity of the optical recording medium 10, and cracks may be generated in the optical recording medium 10 owing to stress present in the first dielectric layers 15 and/or the second dielectric layer 13.

[0031]

The recording layer 14 is a layer in which a recording mark is to be formed and includes a reaction layer 31 and a reaction layer 32 in contact with the reaction layer 31. The reaction layer 32 is disposed on the side of the substrate 11 and the reaction layer 31 is disposed on the side of the light transmission layer 16. As shown in Figure 3 (a), the reaction layer 31 and the reaction layer 32 are laminated at an unrecorded region of the recording layer 14. When the recording layer 14 is irradiated with a laser beam having a predetermined power or more, the element contained in the reaction layer 31 as a primary component and the element contained in the reaction layer 32 as a primary component partially or totally diffuse by heat generated by the laser beam to mix with each other, whereby a recording mark is formed, as shown in Figure 3 (b). As a result, since the reflection coefficient of a mixed region of the recording layer where the recording mark is formed and that of other regions of the recording layer with respect to a laser bream for reproducing data are greatly different from each other, data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in reflection coefficient therebetween.

[0032]

In this embodiment, the reaction layer 31 contains one element selected from the group consisting of C, Si, Ge and Sn as a primary component and the reaction layer 32 contains the other element selected from the group consisting of C, Si, Ge and Sn as a primary component. Each of C, Si, Ge and Sn has a low absorption rate (lower than about 20 %) with respect to a laser beam having a wavelength included in a red wavelength region in which the wavelength λ is equal to or longer than 550 nm and equal to or shorter than 850 nm but has a high absorption rate (equal to or higher than about 40 %) with respect to a laser beam

having a wavelength included in a blue wavelength region in which the wavelength λ is equal to or longer than 350 nm and equal to or shorter than 450 nm. Therefore, each of C, Si, Ge and Sn is suitable as a material for forming a recording layer of the next-generation type optical recording medium in which data are recorded using a laser beam having a wavelength included in a blue wavelength region. Further, each of C, Si, Ge and Sn puts minimal load on the environment.

[0033]

Moreover, it is preferable to add Cu, Au, Ag, Pd, Pt, Fe, Ti, Mo, W or Mg to the reaction layer 31 and/or the reaction layer 32 in addition to a primary component element. By adding at least one element selected from the group consisting of Cu, Au, Ag, Pd, Pt, Fe, Ti, Mo, W and Mg to the reaction layer 31 and/or the reaction layer 32, it is possible to improve the surface smoothness of the reaction layer 31 and/or the reaction layer 32 and decrease the noise level of the reproduced signal. Further, since these elements put minimal load on the environment, even if one of these elements is added to the reaction layer 31 and/or the reaction layer 32, it is possible to prevent load applied onto the environment from increasing. Here, it is not absolutely necessary to add one element among these elements to the reaction layer 31 and/or the reaction layer 32 and two or more elements selected from these elements may be added to the reaction layer 31 and/or the reaction layer 32.

[0034]

As the thickness of the recording layer 14 becomes thicker, the surface smoothness of the surface 31a of the reaction layer 31 irradiated with the beam spot of the laser beam becomes worse so that the noise level of a reproduced signal increases and the recording sensitivity of the recording layer 14 becomes lower. Considering these, it is effective to set

the thickness of the recording layer 14 thinner in order to improve the surface smoothness of the surface 31a of the reaction layer 31 so that the noise level of a reproduced signal can be suppressed and the recording sensitivity of the recording layer 14 can be improved but in the case where the thickness of the recording layer 14 is set too thin, the change in the optical characteristics between before and after the recording of data, so that a reproduced signal having high strength (C/N ratio) cannot be obtained. Further, in the case where the thickness of the recording layer 14 is set too thin, it becomes difficult to control the thickness of the recording layer 14. Considering these, it is preferable to set the thickness of the recording layer 14 to 2 nm to 30 nm, it is more preferable to set the thickness thereof to 3 nm to 24 nm and it is particularly preferable to set the thickness thereof to 5 nm to 12 nm.

[0035]

The individual thicknesses of the reaction layer 31 and the reaction layer 32 are not particularly limited but in order to considerably suppress the noise level of a reproduced signal, considerably improve the recording sensitivity and greatly increase the change in reflection coefficient between before and after the recording of data, the thickness of each of the reaction layer 31 and the reaction layer 32 is preferably from 1 nm to 30 nm. Further, it is preferable to define the ratio of the thickness of the reaction layer 31 to the reaction layer 32 (thickness of reaction layer 31 / thickness of the reaction layer 32) to be from 0.2 to 5.0.

[0036]

The light transmission layer 16 constitutes a light incidence plane of the laser beam and serves to transmit a laser beam. The light transmission layer 16 preferably has a thickness of 10 μm to 300 μm. More preferably, the light transmission layer 16 has a thickness of 50 μm

to 150 μm. The material used to form the light transmission layer 16 is not particularly limited but an acrylic ultraviolet ray curable resin or an epoxy ultraviolet ray curable resin is preferably used for forming the light transmission layer 16. Instead of forming the light transmission layer of an acrylic ultraviolet ray curable resin or an epoxy ultraviolet ray curable resin, the light transmission layer 16 may be formed using a sheet made of light transmittable resin, various adhesive agents and agglutinants.

[0037]

The optical recording medium 10 having the above-described configuration can, for example, be fabricated in the following manner.

[0038]

The reflective layer 12 is first formed on the substrate 11 formed with the grooves 11a and lands 11b. The reflective layer 12 can be formed by a gas phase growth process using chemical species containing elements for forming the reflective layer 12. Illustrative examples of the gas phase growth processes include vacuum deposition process, sputtering process and the like. Next, the second dielectric layer 13 is formed on the surface of the reflective layer 12. The second dielectric layer 13 can be also formed by a gas phase growth process using chemical species containing elements for forming the second dielectric layer 13.

[0039]

The second reaction layer 32 constituting the recording layer 14 is then formed on the second dielectric layer 13. The second reaction layer 32 can be also formed by a gas phase growth process using chemical species containing elements for forming the second reaction layer 32 in the similar manner to that for forming the second dielectric layer 13. The first reaction layer 31 is further formed on the second reaction layer 32.

The first reaction layer 31 can be also formed by a gas phase growth process using chemical species containing elements for forming the first reaction layer 31.

[0040]

The first dielectric layer 15 is then formed on the first reaction layer 31. The first dielectric layer 15 can be also formed by a gas phase growth process using chemical species containing elements for forming the first dielectric layer 15.

[0041]

Finally, the light transmission layer 16 is formed on the first dielectric layer 15. The light transmission layer 16 can be formed by applying acrylic ultraviolet curing resin or epoxy ultraviolet curing resin whose viscosities are adjusted onto the first dielectric layer 15 to form a coating layer, projecting an ultraviolet ray onto the coating layer and curing the acrylic ultraviolet curing resin or epoxy ultraviolet curing resin. Thus, the optical recording medium 10 was fabricated.

[0042]

Here, a method for fabricating an optical recording medium is not limited to the above described method and a known technique for fabricating an optical recording medium can be used for fabricating the optical recording medium 1 of the present invention.

[0043]

Next, an optical recording method using the optical recording medium 10 will be explained below.

[0044]

As shown in Figure 1, the recording layer 14 of the optical recording medium 10 is first irradiated via the light transmission layer 16 with a laser beam L10 having predetermined power. It is necessary for

the wavelength of the laser beam L10 to be included in a blue wavelength region in which the wavelength λ is equal to or longer than 350 nm and equal to or shorter than 450 nm and it is preferable to use a laser beam L10 having a wavelength of about 405 nm. The numerical aperture of an objective lens for converging the laser beam L10 is preferably 0.7 or more and more preferably about 0.85. Thus, it is preferable to use the laser beam L10 and the objective lens whose numerical aperture NA and wavelength λ satisfy $\lambda/NA \leq 640$ nm.

[0045]

When the recording layer 14 is irradiated with the laser beam L10, the element contained in the reaction layer 31 and the element contained in the reaction layer 32 are heated by the laser beam L10 and these elements move and mix with each other. As shown in Figure 2 (b), a region formed by mixing the element contained in the reaction layer 31 and the element contained in the reaction layer 32 forms a recording mark M. Since the reflection coefficient of the mixed region where the recording mark has been formed is greatly different from that of other regions (unrecorded regions) of the recording layer 14, data can be recorded in and reproduced from the optical recording medium 10 utilizing the difference in the reflection coefficient therebetween. Here, in the case where a laser beam L10 having a wavelength included in a red wavelength region in which the wavelength λ is equal to or longer than 550 nm and equal to or shorter than 850 nm is used instead of the laser beam L10 having a wavelength included in a blue wavelength region, since the energy of the laser beam L10 is not sufficiently absorbed in the recording layer 14, it is difficult to form a recording mark M.

[0046]

Further, since the recording layer 14 is held between the first

dielectric layer 15 and the second dielectric layer 13, it is possible to effectively prevent the substrate 11 and the light transmission layer 16 from being thermally deformed at the region irradiated with the laser beam L10.

[0047]

As described above, since the optical recording medium 10 according to this embodiment is provided with the recording layer 14 formed by laminating the reaction layer 31 containing one element selected from the group consisting of C, Si, Ge and Sn as a primary component and the reaction layer 32 containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component, it is possible to form a recording mark using a laser beam having a wavelength included in a blue wavelength region used for recording data in the next-generation type optical recording medium and it is possible to reduce load applied onto the environment.

[0048]

The present invention has thus been shown and described with reference to a specific embodiment. However, it should be noted that the present invention is in no way limited to the details of the described arrangements but changes and modifications may be made without departing from the scope of the appended claims.

[0049]

For example, in the optical recording medium 10 according to the above described embodiment, although the recording layer 14 is held between the first dielectric layer 15 and the second dielectric layer 13, one or both of them may be omitted.

[0050]

Further, in the optical recording medium 10 according to the

above described embodiment, although the recording layer 14 is constituted by the two reaction layers laminated on each other, an optical recording medium of the present invention is not limited to that having such configuration and an optical recording medium may include a recording layer constituted by three or more layers insofar as the recording layer includes a first reaction layer containing one element selected from the group consisting of C, Si, Ge and Sn as a primary component and the second reaction layer containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component and formed in contact with the first reaction layer. For example, an optical recording medium may include a recording layer having a three layer configuration including two first reaction layers each containing one element selected from the group consisting of C, Si, Ge and Sn as a primary component and one second reaction layer containing the other element selected from the group consisting of C, Si, Ge and Sn as a primary component and disposed between the first reaction layers and a mixed layer formed by mixing the material contained in the first reaction layer as a primary component and the material contained in the second reaction layer as a primary component may be disposed between the first reaction layer and the second reaction layer.

[0051]

Furthermore, in the optical recording medium 10 according to the above described embodiment, although the reaction layer 31 and the reaction layer 32 are in contact with each other, it is possible to dispose another layer such as a dielectric layer between the reaction layer 31 and the reaction layer 32. However, if such a layer is too thick, since the technical effects of the present invention cannot be obtained in a desired

manner, it is necessary to set the thickness of such a layer to be equal to or thinner than 30 nm and it is preferable to set it to be equal to or thinner than 20 nm.

[0052]

Moreover, in the optical recording medium 10 according to the above described embodiment, although the reflective layer 12 is formed on the substrate 11, in the case where the difference in the levels between light reflected from the region where a recording mark M is formed and unrecorded regions is considerable large, the reflective layer 12 may be omitted.

[0053]

Further, in the optical recording medium 10 according to the above described embodiment, although the optical recording medium 10 includes the vary thin light transmission layer 16, the present invention is not limited to application to such an optical recording medium and the present invention can be applied to any of various DVD type optical recording media insofar as the optical recording medium is constituted so that a recording mark can be formed by projecting a laser beam having a wavelength included in a blue wavelength region onto a recording layer.

[0054]

[WORKING EXAMPLES]

Hereinafter, working examples will be set out in order to further describe the present invention concretely. However, the present invention is in no way limited to the working examples.

[0055]

[Preparation of Optical Recording Medium 1]

<u>Working Example 1</u>

An optical recording medium having the same configuration as

that of the optical recording medium 10 shown in Figure 1 except that the reflective layer 12 was omitted was fabricated in the following manner.

[0056]

More specifically, a polycarbonate substrate 11 having a thickness of 1.1 mm and a diameter of 120 mm was first set on a sputtering apparatus. Then, a second dielectric layer 13 containing a mixture of ZnS and SiO_2 and having a thickness of 60 nm, a reaction layer 32 containing Si as a primary component and having a thickness of 6 nm, a reaction layer 31 containing Ge as a primary component and having a thickness of 6 nm and a first dielectric layer 15 containing the mixture of ZnS and SiO_2 and having a thickness of 60 nm were sequentially formed on the polycarbonate substrate using the sputtering process.

[0057]

Further, the first dielectric layer 15 was coated using the spin coating method with an acrylic ultraviolet curing resin to form a coating layer and the coating layer was irradiated with ultraviolet rays, thereby curing the acrylic ultraviolet curing resin to form a light transmission layer 16 having a thickness of 100 μm.

[0058]

The mole ratio of ZnS to SiO_2 in the mixture of ZnS and SiO_2 contained in the first dielectric layer 15 and the second dielectric layer 13 was 80:20.

[0059]

<u>Working Example 2</u>

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Ge as the primary component and a reaction layer 31 containing Si as the primary

component were formed.

[0060]

Working Example 3

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing C as the primary component was formed.

[0061]

Working Example 4

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Ge as the primary component and a reaction layer 31 containing C as the primary component were formed.

[0062]

Working Example 5

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing C as the primary component and a reaction layer 31 containing Si as the primary component were formed.

[0063]

Working Example 6

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 31 containing C as the primary component was formed.

[0064]

Working Example 7

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Sn as the primary component was formed.

[0065]

Working Example 8

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Ge as the primary component and a reaction layer 31 containing Sn as the primary component were formed.

[0066]

Working Example 9

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Sn as the primary component and a reaction layer 31 containing Si as the primary component were formed.

[0067]

Working Example 10

An optical recording medium was fabricated in the manner of Working Example 1, except that a reaction layer 32 containing Si as the primary component and a reaction layer 31 containing Sn as the primary component were formed.

[0068]

[Evaluation]

Information was optically recorded in each of the optical recording media fabricated in accordance with Working Examples 1 to 10 in the following manner.

[0069]

First, each of the optical recording media fabricated in accordance with Working Examples 1 to 10 was set in an optical recording medium evaluation apparatus "DDU1000" (Product Name) manufactured by Pulstec Industrial Co., Ltd. Then, a laser beam having a wavelength λ of

405 nm was converged onto each of the optical recording media using an objective lens having a numerical aperture NA of 0.85 and was projected onto the recording layer 14 from the side of the light transmission layer 16, thereby optically recording data therein. As recording signals, a 2T signal and an 8T signal in (1.7) RLL Modulation Code. Further, the channel bit length was set to 0.12 μm, the linear recording velocity was set to 5.3 m/sec and the channel clock was set to 66 MHz.

[0070]

Further, a laser beam having a wavelength λ of 405 nm was converged onto each of the optical recording media fabricated in accordance with Working Examples 1 to 10 and recorded with a 2T signal and an 8T signal using an objective lens having a numerical aperture NA of 0.85 and was projected onto the recording layer 14 from the side of the light transmission layer 16, thereby reproducing a 2T signal and an 8T signal.

[0071]

As a result, the reproduced signal having highest C/N ratio was obtained for each of the optical recording media when data were recorded using the laser beam having the power shown in Table 1 and the C/N ratio of the reproduced signal obtained at the power of the laser beam was shown in Table 1. The maximum power of the laser beam of the optical recording medium evaluating apparatus used for the experiment was 10.0 mW. Therefore, when the C/N ratio did not saturate even though the power of the laser beam was increased up to 10.0 mW, it was deemed that the power of the laser at which the reproduced signal having the maximum C/N ratio would be obtained exceeded 10.0 mW. This is indicated by designating the power value of the laser beam as 10.0 mW. The power of the laser beam was defined as the power of the

laser beam on the surface of the optical recording medium.

[0072]

Table 1

	First Reaction Layer	Second Reaction Layer	2T C/N (dB)	8T C/N (dB)	Laser Beam Power (mW)
Working Example 1	Ge	Si	24.0	46.6	10.0*
Working Example 2	Si	Ge	31.8	41.3	8.0
Working Example 3	Ge	C	25.2	46.1	7.0
Working Example 4	C	Ge	24.2	45.4	9.0
Working Example 5	Si	C	31.5	42.1	7.0
Working Example 6	C	Si	31.6	43.9	10.0*
Working Example 7	Ge	Sn	29.0	41.4	8.5
Working Example 8	Sn	Ge	21.0	50.6	10.0*
Working Example 9	Si	Sn	34.4	49.6	6.0
Working Example 10	Sn	Si	32.6	42.1	5.0

The power value of the laser beam affixed with an asterisk indicates that the power value of the laser beam was fixed to 10 mW because it was expected that the power of the laser beam at which the reproduced signal having the maximum C/N ratio would be obtained exceeded 10.0 mW.

As apparent from Table 1, it was found that the C/N ratio of the

reproduced signal was of a measurable level in each of the optical recording media fabricated in accordance with Working Examples 1 to 10. In other words, it was confirmed that a signal could be recorded in each of the optical recording media fabricated in accordance with Working Examples 1 to 10 when the laser beam having a wavelength λ of 405 nm was used. Further, in each of the optical recording media fabricated in accordance with Working Examples 2 to 5, 7, 9 and 10, the power of the laser beam at which the reproduced signal having the maximum C/N ratio was obtained was low (smaller than 10 mW) and it was confirmed that each of the optical recording media fabricated in accordance with Working Examples 2 to 5, 7, 9 and 10 had a high recording sensitivity.

[0073]

[TECHNICAL ADVANTAGE OF THE INVENTION]

As described above, according to the present invention, it is possible to record a signal therein using a laser beam having a wavelength included in a blue wavelength region and it is possible to reduce load applied onto the environment.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Figure 1]

Figure 1 is a schematic cross-sectional view showing the structure of an optical recording medium that is a preferred embodiment of the present invention.

[Figure 2]

Figure 2 (a) is an enlarged cross sectional view schematically showing a region of an optical recording medium where no data are recorded and Figure 2 (b) is an enlarged cross sectional view schematically showing a region of an optical recording medium where a

recording mark M is formed.

[BRIEF DESCRIPTION OF REFERENCE NUMERALS]

10 ..... an optical recording medium

11 ..... a substrate

11a ..... a land

11b ..... a groove

12 ..... a reflective layer

13 ..... a second dielectric layer

14 ..... a recording layer

15 ..... a first dielectric layer

16 ..... a light transmission layer

17 ..... a hole

31, 32 ..... a reaction layer

31a ..... a surface of a reaction layer

L10 ..... a laser beam

M ..... recording mark

FIG. 1

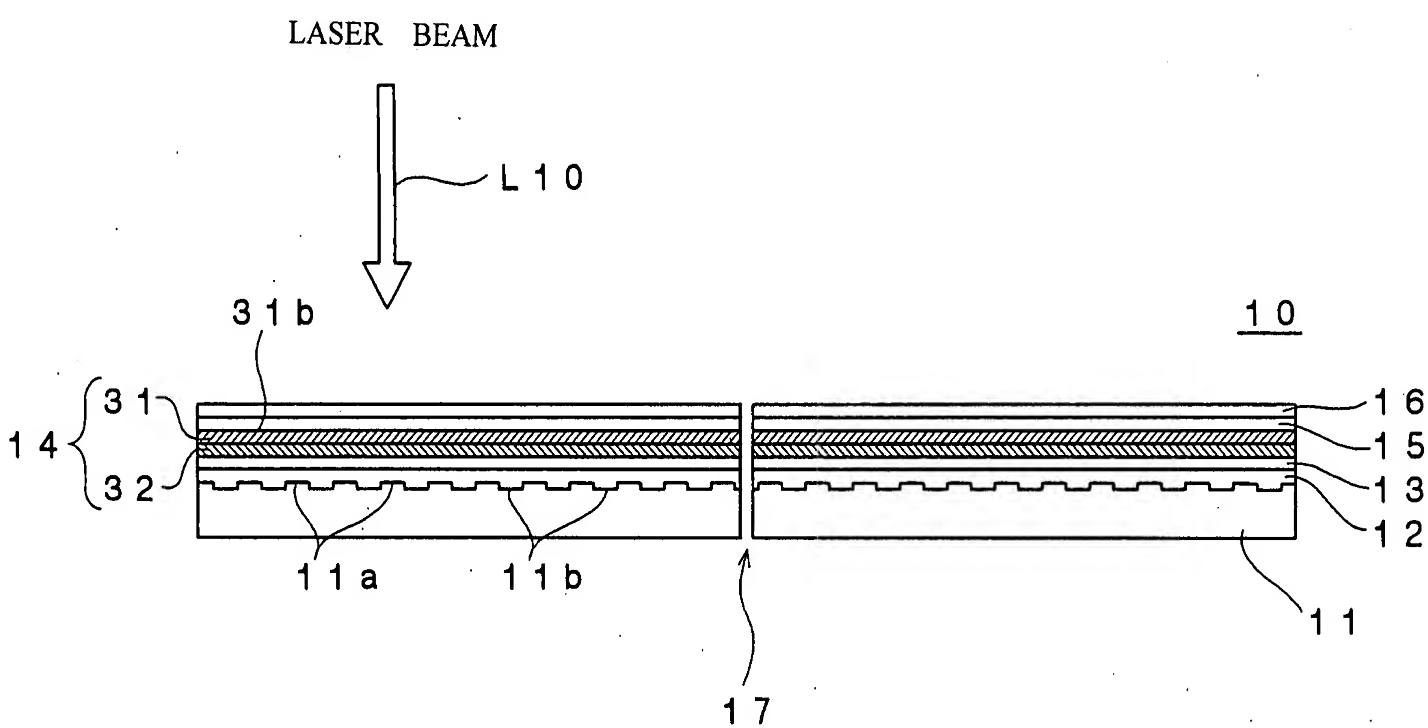
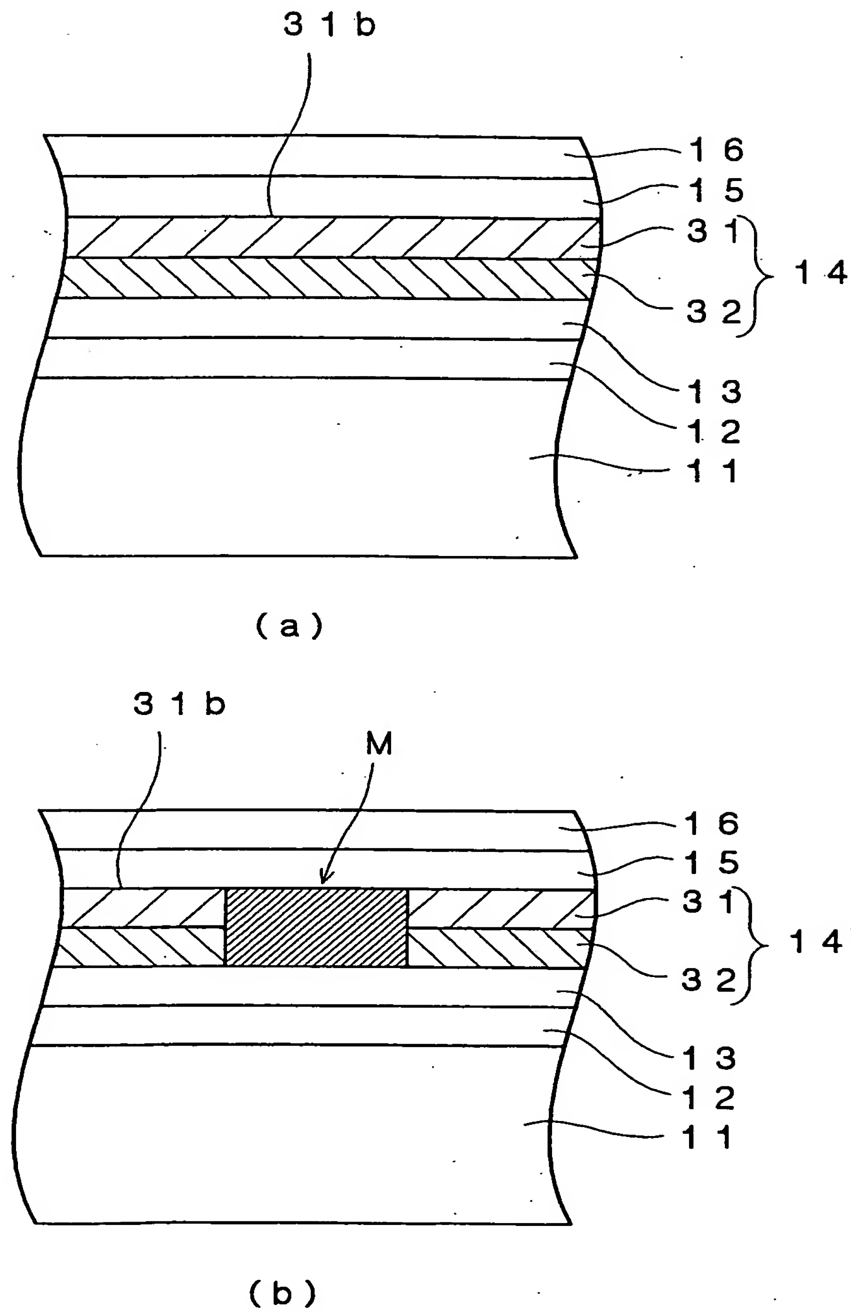


FIG. 2



[Name of Document] ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problems]

It is an object of the present invention is to provide an optical recording medium whose recording layer is constituted by a plurality of reaction layers each containing an inorganic material and in which data can be recorded using a laser beam having a wavelength included in a blue wavelength region and which can reduce load applied onto the environment.

[Solutions]

An optical recording medium includes a substrate 11 and a recording layer 14 formed over the substrate 11 and is adapted so that a recording mark M is formed at a predetermined region of the recording layer 14 by projecting a laser beam L10 having a wavelength of 350 nm to 450 nm. The recording layer 14 includes a reaction layer 31 containing one element selected from a group consisting of C, Si, Ge and Sn as a primary component and a reaction layer 32 disposed adjacent with the reaction layer 31. According to the thus constituted optical recording medium, it is possible to record information therein using the laser beam having a wavelength included in a blue wavelength region suitable for achieving high recording density and a high data transfer rate.

[Selected Figure] Figure 2